The collaboration between Int J Life Cycle Assess and J LCA Jpn

Yasunari Matsuno · Yasushi Kondo

1 Preamble

The Institute of Life Cycle Assessment, Japan (ILCAJ) was established in October 2004. The goal of ILCAJ is to promote academic activities related to life cycle thinking and to share expert knowledge with colleagues from wider ranging backgrounds. Professor Ryoichi Yamamoto, University of Tokyo, has taken responsibility as Chairman of ILCAJ.

In April 2005, ILCAJ has successfully established its publication organ (in Japanese), The Journal of Life Cycle Assessment, Japan (J LCA Jpn). The issues appear every 3 months. J LCA Jpn publishes peer-reviewed research articles, commentaries and discussions, (technical) reports, lecture notes, and presentations of research groups in Japan, along with others. In Int J Life Cycle Assess 12(6):348–350, we were happy to announce the collaboration with J LCA Jpn for the purpose of exchanging knowledge, new insights, experiences, and information across the different languages.

The corner J LCA Jpn aims to be a bridge between the LCA community of Japan and that of the whole world. All abstracts of research articles published in J LCA Jpn, as well as commentaries and discussions, will simultaneously appear in Int J Life Cycle Assess, Corner: J LCA Jpn, in order to introduce Japanese activities to our readers. In addition, some selected research papers from J LCA Jpn will be submitted to Int J Life Cycle Assess for publication following peer review. We hope that this collaboration will stimulate the global exchange of information through professional pathways. The following abstracts were published in J LCA Jpn Vol. 4, No. 3 (July).

2 Commentaries and discussions

2.1 The roadmap of "sustainable manufacturing" and the role of eco-design

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Objective To perform strategic R&D, the role of a technological roadmap is very important. Road-mapping is neither a "research" nor "development" in itself. But, it is an indispensable effort in determining a research target, proposing a new research project, or funding a research project. Especially, "global warming" has been an urgent issue throughout the world in recent times. And to announce a countermeasure for the issue, predicting future technological progress which can contribute to implement sustainable society and societal conditions is really necessary. For this purpose, New Energy and Industrial Technology Development Organization (NEDO) was consigned

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an investigation "Technological Road-mapping of Sustainable Manufacturing Technology" from Ministry of Economy, Trade and Industry (METI). In the article, the author tries to introduce the effort of road-mapping and to relate sustainable manufacturing technologies mentioned in the roadmap to eco-design technologies.

Role of eco-design Eco-design is considered to be the same term as environmentally conscious design. This is true, but there are many design targets such as society, manufacturing systems, manufacturing processes, and products. Eco-design technologies can focus on particular design targets, but the effect of eco-design should be positive for a wide area of our society. Eco-design should be an integrated technology which focuses on the global effects of design in the aspect of space and time. We also need to be aware of the limit and necessary condition of eco-design. Eco-design should be a technology which can contribute, not only toward reducing the environmental impact of human activities, but also toward enhancing quality-of-life and industrial competitiveness.

Sustainable manufacturing and eco-design In the effort of road-mapping, the committee set four major areas of sustainable manufacturing, which are "green biotechnologies," "green sustainable chemistry," "3R technologies," and "design, manufacturing and fabrication technologies." The author belonged to the working group which discussed the last area. As a result of the investigation, we subdivided the area into four major technological approaches that are "life cycle thinking," "minimizing," "value enhancement," and "technology transfer." We found that many of the eco-design-related technologies are categorized to the technological approach which is called "life cycle thinking." As the result of the effort to relate eco-design technologies with sustainable manufacturing roadmap, it was clarified how eco-design technologies are located in the Japanese R&D strategy and how eco-design technologies should be progressed.

2.2 Recent trends of eco-design: eco-design of electric appliances

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This paper describes an overview of recent developments and practices on eco-design of electric appliances. It consists of four major parts involving circumstances surrounding eco-design, practices of eco-design in the Japanese electric appliances industry, indicators for evaluation, and international standardization. The first part shows an overall picture of the movements and trends in the world on eco-design, and its fundamental way for improving the environmental performance of products under these circumstances is also presented. The second part describes the typical practices as examples of eco-design activities in the industry. Many kinds of conditions are reflected as follows: to reduce, reuse, and recycle materials and electric appliances are dominant factors in wastes and resources problems, energy efficiency is a globally emerging issue, and treatment of chemical substances must be severely controlled. The third part explains practical research and developments on environmental performance indicators for manufacturers to communicate with consumers. Eco-efficiency can be defined with two significant aspects of a product: functional performance and environmental impact. Factor-X is a specialized indicator expressing the improvement of each product's value or benefit and environmental friendliness at the same time. An evaluating methodology associated with four electrical appliances including air-conditioners, refrigerators, lamps, and lighting apparatus are also presented. The last part introduces a new movement for the international standardization of eco-design and Japan's contributions to its technological considerations. Through these perspectives, the author emphasizes the significance of eco-design to compete in the present and future markets of electrical appliances and to transform the consumers' lifestyles as a key driver toward sustainable development.

2.3 Recent perspective of eco-design in building

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This article summarizes the historical evolution of the idea of eco-design in building-related industries. The idea has been generated from the idea of environmental symbiosis as an alternative concept of modern buildings where the environment which has been built is artificially and proactively controlled. Then, influenced by the Bruntland report, the idea of sustainable building has been developed. Some understand the word sustainable only literally and strictly and try to disseminate the examples of autonomous buildings. Contrarily, the majority understand sustainable building to be less-unsustainable buildings. Radical and incremental innovations are progressing in the process of a diffusion of sustainable buildings. Building professions tend to apply holistic approaches rather than insisting on the application of specific technology. The diffusion of sustainable buildings requires a preparation of common yardsticks outlining the environmental performance of a building. Since the early 1990s, BREEAM, LEED, and CASBEE have

developed and disseminated an environmental performance assessment method of building. This involves market-based assessment methods by which many stakeholders can communicate about better buildings from the aspect of environmental performance. Though the methods are too highly outlined from the aspect of rigor theory of LCA, the methods are used well on the market place. Finally, the article introduces an international standardization of environmental performance for the assessment method of building.

2.4 Eco-design of urban and regional systems: sustainable region management toward low carbon and resource recycling-oriented society

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The concept of eco-design is applicable not only to the products and buildings, but also to the urban and regional systems. In this paper, we overviewed the research approaches and sustainability indicators to plan or evaluate the low carbon, natural symbiosis, and resource recycle-oriented society at the regional level, especially focusing on the material and energy flows. In addition, we showed that the carbon management in the product chain was becoming important when planning the practical actions for a low carbon society in Japan.

2.5 The EuP directive: current status and steps towards implementation

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The framework directive for eco-design of energy-using products (EuP) has already been in force in Europe since 2005, but the process for setting eco-requirements for specific products is only now becoming clear. The paper explains the results of the so-called preparatory studies, which prepare the definition of eco-requirements, and the current state of the policy process. The paper gives a short introduction to the EuP directive itself, explains the procedure leading up to implementing measures in more detail, and shows the respective time lines. Then, the paper exemplifies the results of selected preparatory studies with respect to eco-design recommendations. Finally, the focus is set on specific aspects related to the application of life cycle assessment principles in conjunction with environmental policy making.

2.6 Japanese electrical and electronic industry in response to the EuP directive

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The sixth environment action plan was adopted in Europe in 2002, and the prioritized areas of the environmental policy were indicated. The Integrated Products Policy (IPP), which was based on this, was also announced. This policy aims at reducing environmental impact through the life cycle of the product by the extension of the product life, energy saving in used, reused, and recycled parts of the product. To achieve this, environmental labels, green procurement, eco-design, and national subsidy are used as the policy tools. And it will push forward environmental improvement and performance improvement of the product by their synergetic effect. In such a situation, the "Framework Directive for Setting Eco-design Requirements for Energy-using Products" was suggested as the directive concerned with the environmental consideration for design of such energy-consumer products as electrical equipment and heaters. It was adopted in July 2005 by the European Commission (2005/32/EC). This directive, in general terms, is called the "EuP directive." In this paper, the summary of the EuP directive, Japanese companies' responses to this EuP, and the recent trends of the EuP directive are presented. Furthermore, mainly in the domain of personal computers, the latest trends of international energy and the environment evaluation labeling of a product, which seems to greatly affect the future EuP directive, are explained.

3 Research articles

3.1 Introduction of LCA into design process on SME

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Objective Eco-design tools, which are widely utilized by major manufactures, have not been spread over small- and medium-sized enterprises (SMEs). SMEs do not have an incentive to implement eco-design tools for the following reasons: (1) Many SMEs are standing at the middle position of the product supply chains. Therefore, they receive the specifications of their products from their customers and they have small flexibility of design and production procedures. (2) Shortage of information on the upper and the lower stages of the product supply chains make implementing eco-design tools difficult. (3) SMEs

do not have enough capacity to install new tools due to lack of staff and budget for research and development. To overcome these obstacles, we have implemented the Eco-design Promotion Project for SME, to diffuse eco-design tools, i.e., life cycle assessment (LCA) and quality function deployment for environment (QFDE). This paper introduces the results of the project and proposes a model of design process.

Results and discussion The number of companies that participated in the project was 14 in 2006FY and 63 in 2007FY. As examples, two cases observed in 2006FY are shown in this paper. In case of the ventilation system, the company implemented QFDE and LCA for the fan and clarified that CO_2 emission through the product life cycle is dominated by the usage stage. The designers found that a redesign of the shape of the blade to reduce the power consumption in the usage stage is effective to improve the environmental performance. In the case of the casting products, the company applied LCA to improve its production line because the detailed product design is strictly specified by its customer. The LCA quantified that the dominant factor was the energy consumption in cupola furnace and the pig iron production. The company found that the improvement of process yield and reducing the feed amount of pig iron are effective. To implement LCA and QFDE for SME effectively, we have to consider not only the product characteristics, but also every aspect where the SME can contribute to the product, since most SMEs are standing at the middle position of the product supply chains. Furthermore, we have to take into account the variations of the status and condition of environmental data management dependent on the SME. Therefore, we propose a business model for SME to implement eco-design.

Conclusions The paper shows that the eco-design tools can be useful for SME to reduce environmental impact by implementing the right tools in the right timing and by describing practical case studies. Business process models developed by using an IDEF0 function modeling method show when LCA is used and what is needed for the implementation of LCA. Two business process models are proposed to implement LCA on product design processes and on production line design processes.

3.2 Life cycle evaluation of clarification system for circulation of cooling water by electrolyzed effective water

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Objective Slime failure and outbreak of *Legionella* in air-conditioning circulation cooling water systems are generally treated by chemicals. Authors developed a clarification system for circulation cooling water by using electrolyzed effective water (electrolyzed effective water treatment), which has equal or better clarification effects than chemical treatment. In this study, we performed a life cycle inventory analysis (LCIA) with building chemical treatment and electrolyzed effective water treatment process flow. In the chemical treatment process, chemicals are produced in the Kantou area, transported to Nagasaki, and then applied there. The authors also carried out an environmental impact assessment (EIA) using LCIA. The volume of CO_2 emission was calculated between the time of chemical treatment in each area, its transport to Nagasaki and its utilization there, and the electrolyzed effective water treatment in Nagasaki. In addition, the volume of CO_2 emission was calculated and compared between the time of chemical treatment, during which the chemicals are produced in each area and utilized there, and the electrolyzed effective water treatment in each area, respectively.

Results and discussion From the results of LCIA of chemical treatment and electrolyzed effective water treatment in Nagasaki, the global warming index of electrolyzed water treatment and chemical treatment indicated 3,187 and 4,210 kg CO_2, respectively, so that the influence to global warming in the case of clarification by electrolyzed water was smaller than that found for chemical treatment. For the result of this single index, the influence of chemical treatment was larger than for electrolyzed effective water treatment. Especially, the influence of urban area air pollution was remarkably larger because of discharge of NO_x, PM10, and hydrocarbons in the transportation of chemicals. In the case of chemical treatment in Nagasaki, it was cleared that the area in which chemicals are produced has more influence than transportation distance for chemicals with regard to CO_2 emission in all process flows. In the case of electrolyzed effective water treatment in each area of Japan, CO_2 emission is lower than for chemical treatment, and in the case of its chemical products in each area.

Conclusions In this study, life cycle impact assessment of electrolyzed, effective water treatment and chemical treatment in Nagasaki. According to the result of a single index, electrolyzed effective water treatment was lower than chemical treatment. And it was cleared that the volume of CO_2 emission of electrolyzed effective water treatment in each area was

smaller than for chemical treatment of the chemicals that are produced in each area and utilized in there.

3.3 life cycle analysis due to bio-DME synthesis system considering the BTL plant scale

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Objective In this paper, we focused on biomass dimethyl ether (bio-DME) in biomass-to-liquid (BTL) fuel liquefaction system through a gasification process. Based on the bottom-up methodology, the inventories of CO_2 emissions and energy intensities were estimated. In the system boundary, the subsystems of the preprocessing, the energy conversion, and the fuel transportation were included. Considering the scale and the operational conditions (an inner pressure and a reaction temperature) of a BTL plant, the inventories were estimated. Also, the uncertainties in the preprocessing, that is, the moisture content of biomass materials and the transportation distance to the plant were simulated by the Monte Carlo simulation. In the preprocessing, there were three processes of chipping, transportation, and dryer. In the energy conversion, we executed the process design on the following two types: the medium scale of BTL plant through pressurized fluidized bed gasification and the small one through BLUE Tower (BT) process were assumed. Both plants have a liquefaction process. Also, due to the process design, the auxiliary power of each plant was considered. In addition, the liquefied fuel (bio-DME) was assumed to be delivered using a 10-kl tank truck.

Results and discussion As a results, in the small-scale plant (BT process), CO_2 emissions of 45.8–60.5 g CO_2/MJ and energy intensities of 1.44–1.63 MJ/MJ were obtained. Conversely, in the medium-scale plant, CO_2 emissions of 22.5–51.6 g CO_2/MJ and energy intensities of 0.29–0.66 MJ/MJ were obtained.

Conclusions From the viewpoint of the environmental statement, bio-DME was likely to be superior to DME of natural gas origin.

3.4 Uncertainty analysis for LCA of passenger cars as a case study

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Objective Generally, the environmental impacts of products are assessed based on the deterministic data (ex. mean value) for inventory analysis and impact assessment in life cycle assessment. However, both inventory data and impact factors have some uncertainties. In this research, a case study for passenger cars was conducted to clearly show the importance of uncertainty analysis in LCA.

Results and discussion Inventory data containing statistical data were referred to Ecoinvent (LCI database in Switzerland) and some part of the data were revised to reflect Japanese conditions based on the LCI data provided by the Japan Automobile Research Institute (JARI). "Life Cycle Impact Assessment Method Based on Endpoint Modeling (LIME)" was applied as an impact assessment method, and uncertainty data of impact factors were obtained based on Monte Carlo simulation by using results of the investigation for statistical information of each parameter. In the comparison of gasoline-powered (GV, 2000 regulation) and diesel-powered vehicles (DV, 2002 regulation), the environmental impact of DV was higher in the assessment based on deterministic data. However, the results of uncertainty analysis quantitatively showed that the conclusion obtained from the deterministic analysis was not always supported, indicating that there is still a 34% possibility that the opposite conclusion is suggested. Factors with high sensitivity on the uncertainty of impact assessment results have been clarified, and the revision of the factors (damage factors for urban air pollution) for reflecting more realistic conditions could have provided more reasonable results.

Conclusions The uncertainty analysis in LCA will be helpful for assessing and improving the reliability of the results and support the decision-making in product selection and policy planning with more confidential and highly responsible information.

3.5 Inventory analysis of waste management in Kariya and Chiryu cities

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Objective Environmental impact of waste processing of Kariya and Chiryu cities, Aichi prefecture was quantitatively analyzed by LCA procedures to propose future waste processing. In this study, the system boundary was covered from the generation of municipal solid waste to landfill. We employed three scenarios for the future system to evaluate the amount of CO_2 emission and incinerated ash. Scenario1, 2, and 3 introduced waste power generation, waste by processing direct melting furnaces, and ash melting furnaces, respectively.

Results and discussion A brief outline of each scenario follows: (1) the amount of CO_2 emission is not largely decreased by the introduction of waste power generation, (2) the amount of CO_2 emission increases in the case of scenario 2 because the consumed fuel is large, but the amount of incinerated ash is drastically decreased, and (3) the amount of CO_2 emission increases somewhat in the case of scenario 3 because fuel consumption for ash melting is relatively large, but the amount of incinerated ash is drastically decreased.

Conclusions It is thought that the stringency of the final disposal site, which is the problem of both cities, may be solved by setting up the ash melting furnace in the stoker furnace.

3.6 Use of life cycle thinking in environmental education: visualization and recovery of the missing link towards sustainable consumption

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Background and goal Creating a sustainable society requires changes in people's consciousness and lifestyles, in addition to the development of technologies and use of economic incentives. Environmental education has an important role to play in promoting people's environmental awareness and responsible actions. The goal of this study is to develop teaching material that demonstrates the importance of the life cycle thinking as an important component of effective environmental education.

Methods Focusing on the current situation where daily consumption activities are not linked, in a cognitive sense, to production activities and the natural environment, this study proposes a hypothesis to recover the "missing links" based on life cycle thinking and will subsequently contribute to an increase in the pro-environmental behavior of consumers. Based on this hypothesis, environmental education material was developed that aims to make people realize the "link" between daily life and global warming through the life cycle of consumer products (e.g., mobile phones, notebooks, pens). In order to visualize and effectively recover the "missing link," the LCA software, "Global warming even in your bag?!," that runs on a personal computer and is easy to handle, was newly created as the core of the material.

Results and discussion The material developed was applied to an education program for university students, and a questionnaire survey was conducted to evaluate the effect. Analyses of the survey data indicated that the material is effective in making the students realize the "link" between their daily consumption activities and global warming as well as encouraging behavioral intention towards pro-environmental behavior. In addition, the analyses found that the possibility that the realization of the "link" helps boost their sense of responsibility and improves behavioral intentions toward carbon dioxide reduction.

Conclusions and perspectives The use of life cycle thinking in environmental education is considered effective in encouraging people to engage in more pro-environmental behavior. In the future, first of all, the authors will more appropriately measure the effects of the material developed and elucidate the mechanism of behavioral changes of students. Secondly, we plan to improve the material from a practical perspective and provide a material package available for school education.